GEOMETRIC TESSELLATIONS IN AMANUBAN PLAITING CRAFT: ETHNOMATHEMATICAL PERSPECTIVES AND THEIR INTEGRATION INTO MATHEMATICS LEARNING

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Abstract
Tessellation refers to the complete and repetitive covering of a plane using geometric shapes without gaps or overlaps. While firmly grounded in mathematics, tessellations also manifest in cultural expressions, such as in the patterns of Amanuban palm leaf plaiting craft. This study explores the application of geometric transformations within an ethnomathematical framework, focusing on the structure and motifs found in traditional plaiting crafts. The research identifies three types of tessellations regular, semi-regular, and non-regular (locally referred to as *Duma*) embedded in Amanuban plaiting designs. A qualitative approach was employed, incorporating participatory observation, semi-structured interviews, and visual documentation involving experienced artisans. These cultural practitioners possess deep knowledge of the symbolic meanings and technical processes behind the motifs. The findings reveal that geometric transformations including translation, reflection, rotation, and dilation are applied either consciously or intuitively, resulting in unique aesthetic and cultural patterns. This study confirms that traditional crafts can serve as valuable contextual resources for teaching mathematical concepts, particularly in geometry and tessellation. Integrating cultural heritage into mathematics education enhances students' understanding of mathematics as a discipline embedded in social and cultural contexts. The research contributes to the development of culturally responsive pedagogy and underscores the educational value of local wisdom in fostering meaningful and inclusive mathematics learning.
Keywords: Amanuban Community, Ethnomathematics, Plaiting Craft, Tessellation

INTRODUCTION

Education plays not only a role in intellectual development but also serves as a medium for the preservation and transmission of cultural heritage. In the context of Indonesia, which is rich in cultural diversity, it is essential to implement contextual learning connecting subject matter with local cultural values. One approach that bridges education and culture is ethnomathematics, a field of study that explores how local cultural practices contain and reflect mathematical concepts that can be integrated into learning processes (Fouze & Amit, 2023; Rosa & Orey, 2015; Pradhan 2023).

Mathematics is a fundamental subject taught at all levels of education. In addition to fostering logical and critical thinking skills, mathematics education also cultivates character traits such as perseverance, discipline, and accuracy (Kristia et al., 2021; Fauzan & Anshari, 2024). Moreover, mathematics itself is a cultural product that evolves through human interaction with their environment (Frankenstein & Powell, 2023; Alangui, 2017). It is thus a discipline that is inherently connected to real life and embedded in the cultural fabric of society (Fatimah et al., 2024). This indicates that every cultural group possesses unique mathematical thinking, embedded in daily practices such as counting, measuring, sorting, and designing (Fouze & Amit, 2018). Ethnomathematics, therefore, allows us to view mathematics as a social science rooted in cultural dynamics and local experience (Borba, 1997; Alangui, 2017).

This principle is further reinforced by Frankenstein & Powell (2023), who found that students demonstrate higher performance in solving mathematical problems when the problems are situated in real-life contexts rather than conventional computational tasks. Accordingly, connecting school mathematics with students' cultural practices significantly enhances conceptual understanding and increases learning motivation. When students encounter mathematical values and practices present in their cultural surroundings, they begin to see mathematics not as a foreign or abstract domain but as an integral part of their own lived experiences (Fouze & Amit, 2018; (D’Ambrosio, 2002).

A common issue in formal education is the persistent perception of mathematics as an abstract and difficult discipline. Geometry, as one of the key branches of mathematics, is often considered the most complex topic to teach and learn in schools (Hoffer, 1981; (Fouze & Amit, 2021). Several studies have also revealed that many students face difficulties in understanding spatial concepts and visualizing geometric ideas (Ngirishi & Bansilal, 2019; Ng et al., 2020). These limitations contribute to students’ low proficiency in geometric reasoning and mathematical problem-solving (Cesaria & Herman, 2019; Hendroanto et al., 2018); Sukirwan et al., 2018). Addressing these challenges requires culturally grounded approaches that can help students understand geometric concepts in a more concrete and relatable way.

One such culturally rich artifact is traditional plaiting craft. The palm leaf plaiting craft practices of the Amanuban community, for instance, feature repetitive geometric patterns that can be mathematically identified as tessellations complete fillings of a two-dimensional plane using closed shapes without gaps or overlaps ((Deger & Deger, 2012); Guo & Li, 2020; Aydın-Güç & Hacısalihoğlu-Karadeniz, 2020; (Torrence, 2021); Ali & Davis, 2023). These woven patterns exhibit geometric transformations such as translation, rotation, and reflection, which align with topics covered in school mathematics curricula. Introducing tessellation concepts early in education can foster students' visual and spatial skills (Callingham, 2004), while also strengthening the connection between mathematics and their lived experiences.

Unfortunately, many cultural artifacts that embed mathematical ideas remain underutilized in educational settings. Previous studies have highlighted the relationship between tessellations and local cultures, such as the research by Apiati et al. (2018) on Kampung Naga plaiting craft, Karimah et al. (2021) on Trusmi batik, Ali & Davis (2023) on Adinkra and Kente cultural motifs, Siswo (2019) on plaiting craft practices in Pulobandring, and Yadnya (2016) on ceramics and vavin. However, there has been little research on tessellations in Amanuban plaiting craft, particularly regarding their integration into school mathematics learning. This study is therefore essential to fill that gap by exploring the ethnomathematical potential of Amanuban plaiting craft patterns as a contextual medium for geometry instruction.

Integrating cultural artifacts into learning not only enhances students' cognitive understanding but also enriches their sense of identity and local wisdom (Fatimah et al., 2024). Ethnomathematics offers a culturally responsive approach, providing opportunities for students to explore and appreciate mathematical ideas embedded in art, practices, and everyday life (Pradhan, 2021; D'Ambrosio, 2002). This approach not only makes mathematics more meaningful but also fosters creativity, curiosity, and nurtures multicultural awareness and tolerance (Fouze & Amit, 2018).

This study aims to examine the geometric tessellation patterns found in the traditional plaiting craft of the Amanuban community and analyze their potential integration into mathematics education in schools. It is expected that the findings will contribute to the development of culturally contextualized learning models that are relevant, enjoyable, and meaningful for students.

METHOD

This study employed a qualitative approach using ethnographic methods to investigate the cultural practices of the Amanuban community, particularly in exploring tessellative structures and geometric transformations found in traditional palm leaf plaiting craft motifs. The ethnographic method was selected for its strength in uncovering symbolic meanings and mathematical values embedded in cultural practices through direct engagement between the researcher and the subjects, namely local plaiting artisans.

The research was conducted in the Amanuban region, located in South Central Timor Regency, East Nusa Tenggara, which serves as a central hub for plaiting craft activities and the preservation of local traditions. The primary informants comprised three senior artisans, purposively selected based on their expertise, which included advanced plaiting skills, a deep understanding of motif symbolism, and recognition within the community as cultural custodians.

Data were collected through three main techniques. First, semi-structured interviews were conducted to explore the artisans' in-depth knowledge regarding the creative process, the philosophy behind the motifs, and the recurring patterns in their craft. Second, participant observation was carried out by directly joining the plaiting activities to closely examine natural occurrences of transformations such as translation, rotation, reflection, and dilation within the plaiting process. Third, visual documentation was undertaken through photography, video recordings, and geometric sketches to strengthen field findings and facilitate the visual analysis of tessellation structures.

Data analysis was conducted using a descriptive-qualitative thematic approach. The researcher categorized types of geometric transformations, interpreted visual representations within the motifs, and mapped the interconnections between cultural patterns and mathematical tessellation concepts. Data validity was ensured through triangulation of techniques, which involved cross-verifying the results of interviews, observations, and documentation. Additionally, member checking was conducted with the informants to confirm the accuracy of the interpretations.

RESULTS AND DISCUSSIONS

The traditional plaiting craft of the Amanuban community not only embodies rich cultural and symbolic values but also incorporates complex mathematical concepts that reflect geometric structures, particularly tessellations. Tessellation refers to the complete tiling of a two-dimensional plane using specific geometric shapes without any gaps or overlaps. The patterns found in these plaited designs display systematic repetitions of forms such as squares, parallelograms, rhombuses, and triangles, which can be analyzed according to the classifications of regular, semi-regular, and non-regular tessellations.

According to Guo & Li (2020), tessellations are generally categorized into three main types: regular, semi-regular, and non-regular. A regular tessellation consists of only one type of congruent regular polygon—such as equilateral triangles, squares, or regular hexagons—that fits together uniformly. Semi-regular tessellations involve two or more types of regular polygons arranged in a repeating pattern at every vertex. In contrast, non-regular tessellations feature irregular shapes that still completely cover the plane. As described by Deger & Deger (2012), and Ali & Davis (2023), a tessellation must fill a surface entirely without gaps or overlaps, while maintaining a certain degree of geometric regularity or order.

1. Regular Tessellation

Figure 1. One-Over-One Interlaced Pattern in Plaiting Craft

The traditional plaiting craft presented in Figure 1 exhibits a geometric pattern that clearly reflects the concept of regular tessellation. This pattern is composed of a repetitive arrangement of square units aligned horizontally and vertically, forming a compact and symmetrical grid structure. Each square unit is congruent in size and shape, with four equal-length sides and four right angles. These attributes meet the criteria of a regular polygon a two-dimensional figure with equal sides and equal angles. At each vertex, four squares converge to form a total of 360 degrees, thereby filling the plane completely without gaps or overlaps, in accordance with the fundamental principles of regular tessellation.

The vertex configuration is uniform across the entire pattern, meaning the type and arrangement of polygons meeting at each point remain consistent. Visually, the design also illustrates geometric transformations, including translation where square units are repeated in parallel directions; reflection observable through horizontal and vertical lines of symmetry; and rotation evident in the pattern's symmetry under 180-degree rotation.

From an ethnomathematical perspective, this pattern reveals how Amanuban artisans intuitively apply geometric principles through inherited cultural practices. Despite the absence of formal mathematical language, they produce visually precise and structured patterns tangible expressions of spatial reasoning and geometric proficiency. In primary school mathematics education, this pattern can be used as a contextual tool to introduce concepts such as plane shapes, symmetry, repetition, and geometric transformations. Integrating local cultural heritage with formal geometry supports the aims of the *Merdeka Curriculum*, which emphasizes contextual, meaningful, and culturally grounded learning experiences.

2. Semi-Regular Tessellation

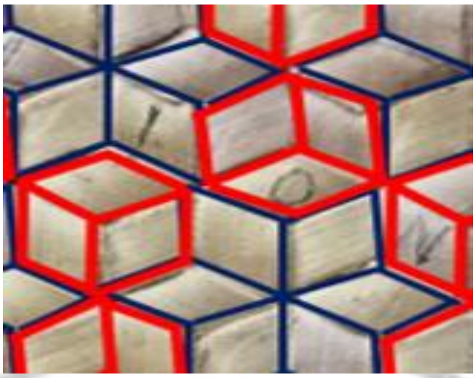

Figure 2. Three-Strand Interlaced Pattern in Plaiting Craft with Two- and Three-Dimensional Forms

The traditional plaiting craft pattern depicted in Figure 2 reveals a complex yet consistently organized geometric structure, featuring two dominant motifs. The first motif creates an illusion of an isometric cube, formed by arranging three parallelograms, while the second resembles a dodecagon, constructed from six parallelograms arranged in a circular configuration. Both motifs completely tile the plane without gaps or overlaps, forming a uniform and repeating pattern that fulfills the fundamental characteristics of tessellation.

This tessellation can be classified as semi-regular, as it incorporates more than one type of geometric shape although not perfect regular polygons while maintaining a consistent overall regularity across the plane. The repetition of structures, regularity of vertices, and uniform connections between units suggest a relatively stable vertex-to-vertex configuration, albeit not as ideal as that found in regular tessellations.

In terms of geometric transformations, the pattern exhibits three main types: translation, evident in the horizontal and vertical repetition of motif units; rotation, observable in the arrangement of parallelograms forming the dodecagon and in the tri-directional orientation of the isometric cubes; and reflection, discernible through visual symmetry along certain axes within the pattern. These transformations demonstrate structural invariance under translation, rotation, and reflection core principles of planar geometry.

From an ethnomathematical perspective, this motif reflects the high visual-spatial reasoning skills of Amanuban artisans, who intuitively construct order and symmetry. Despite the absence of formal geometric instruction, the artisans have, through generations of cultural practice, consistently reproduced patterns that encapsulate sophisticated mathematical ideas, including combinatorial arrangements, reflectional symmetry, and tessellation principles.

Such motifs hold strong potential for integration into contextual mathematics instruction at the junior and senior high school levels. Relevant learning topics include geometric transformations (translation, rotation, reflection), line and rotational symmetry, and the exploration of plane shapes and tessellation configurations. This culturally integrated approach introduces mathematical concepts in an accessible and meaningful way while encouraging students to appreciate local cultural heritage as an authentic and relevant source of knowledge. The incorporation of cultural elements in mathematics education is aligned with the Merdeka Curriculum, which emphasizes meaningful learning, contextualization, and exploration of students' cultural environments.

3. Non-Regular Tessellation

Figure 3. Two-Strand Diagonal Plaiting Pattern

The traditional plaiting craft illustrated in Figure 3 presents a repeating pattern composed of units resembling parallelograms or rhombuses. Each unit is arranged diagonally, forming a consistent crisscross pattern in two opposing directions. While the composition displays a clear sense of visual regularity, it does not meet the criteria for regular or semi-regular tessellation. This is because the base shape used is not a regular polygon such as an equilateral triangle, square, or regular hexagon. Although the individual units appear congruent and successfully tile the plane without gaps or overlaps, the resulting vertex configurations are not uniform across the surface.

The primary feature that classifies this pattern as a non-regular tessellation lies in the geometric properties of its base shape and the inconsistent vertex connections between units. In formal geometry, regular and semi-regular tessellations require uniform vertex arrangements each vertex must be composed of the same types and sequences of polygons. In contrast, the pattern depicted here shows vertex configurations where angles meet sides in varying ways, preventing the formation of a consistent vertex-to-vertex structure. Furthermore, although the parallelograms are repeated, their orientation and alignment create diagonal paths that resemble asymmetrical rotations and translations, reinforcing the irregularity of the overall composition.

This pattern incorporates several geometric transformations. Translation is evident in the repeated diagonal displacement of the parallelogram units. Limited rotational elements can also be observed, particularly in the zigzag sequences formed by the repeating bands. Reflection is less dominant but can still be identified in localized mirror symmetry along certain diagonal lines. Overall, the structure reveals that the plaiting artisan intuitively applies principles of repetition and spatial organization, resulting in a visually coherent arrangement despite the absence of formal mathematical regularity.

From an ethnomathematical perspective, this motif demonstrates that the plaiting practices of the Amanuban community encompass authentic and complex mathematical reasoning. These cultural activities naturally involve competencies in shape recognition, spatial awareness, and pattern construction core elements of geometric thinking. Integrating such motifs into mathematics education at the elementary and secondary levels can offer students meaningful opportunities to explore geometric transformations, plane tiling, and the classification of tessellations based on their structural attributes. Using local cultural designs as teaching materials aligns with the Merdeka Curriculum’s emphasis on contextualized, meaningful, and culturally grounded learning

Figure 4. Three-Strip Interlaced Plaiting Pattern with Three-Dimensional Form

The traditional plaiting craft pattern shown in Figure 4 presents a visual design that resembles a three dimensional cube, formed through the systematic arrangement of rhombic units. Although composed entirely of two-dimensional shapes, the pattern creates an illusion of depth and spatial structure, resulting in a three dimensional optical effect. This illusion is achieved by arranging three rhombi that converge at a single central point in different orientations, giving the impression of the cube's faces. The natural color gradation produced by the palm leaf fibers further enhances the perception of volume and depth.

This structure is categorized as a non-regular tessellation, or more precisely, a pseudo-three-dimensional tessellation. Geometrically, the rhombus used is not a regular polygon, and its arrangement does not produce identical vertex configurations throughout the surface. The variation in the orientation of the rhombi and the irregular connections between units indicate that the pattern does not meet the vertex-to-vertex or edge-to-edge criteria required for regular or semi-regular tessellations. Nevertheless, the pattern successfully covers the plane without gaps or overlaps, thereby fulfilling the fundamental definition of tessellation as outlined.

The geometric transformations embedded within the pattern include translation, visible in the parallel repetition of rhombic units in multiple directions; rotation, evident where three rhombi form radial arrangements simulating the faces of a cube from different angles; and reflection, observed in localized symmetries between adjacent units. These transformations demonstrate that even seemingly complex patterns are rooted in the basic principles of planar geometry.

From an ethnomathematical perspective, this motif reflects the high level of spatial intelligence and intuitive understanding of visual structure possessed by Amanuban artisans. This knowledge is not acquired through formal education but passed down through generations as part of a living cultural tradition. The artisans' ability to create geometric configurations that generate three dimensional visual effects highlights their advanced visual-spatial reasoning and positions this motif as a culturally expressive artifact rich in mathematical significance.

In the context of education, this pattern holds strong potential as a meaningful learning resource in the teaching of geometry, particularly in topics such as geometric transformations, plane figure recognition, and spatial visualization. It is especially relevant for junior and senior high school students, as it supports the development of spatial reasoning skills while fostering appreciation for local cultural heritage. The integration of such patterns into mathematics instruction aligns with the Merdeka Curriculum, which emphasizes contextualized, exploratory, and culturally responsive learning. The pseudo three dimensional tessellation in Amanuban plaiting craft is not merely an aesthetic creation, but a concrete representation of geometric understanding embedded in everyday cultural practice.

Figure 5. Three-Strand Interlacing Pattern with Irregular Two-Dimensional Configuration

The traditional plaiting craft pattern depicted in Figure 5 displays a visual structure composed of irregular triangles and quadrilaterals. Although the base shapes vary in size and angle, the overall pattern successfully covers the plane without leaving gaps or overlaps. This configuration reflects a repetitive and adaptive arrangement of geometric forms that, while intuitive and not governed by formal rules of regular geometry, still adheres to the fundamental principle of tessellation. Therefore, the pattern is best classified as a non-regular tessellation, as it does not satisfy the vertex-to-vertex or edge-to-edge alignment criteria and is not constructed from regular or congruent polygons.

The non-regular characteristics of this pattern arise from the intersection of angles of one shape with the edges of another, rather than forming consistent vertex configurations as required in regular and semi-regular tessellations. The absence of global regularity at the meeting points of the shapes serves as strong evidence that this structure lies outside the standard classifications of tessellation. Nevertheless, the geometric arrangement results in a visually harmonious composition that fulfills the basic requirement of plane coverage without gaps.

Geometric transformations identified within this motif include translation, as seen in the repeated shifting of pattern units in multiple directions; rotation and local reflection, evident in the varying orientations of the triangular and quadrilateral shapes across the pattern. Although global symmetry is absent, the presence of these transformations illustrates how artisans apply geometric principles both functionally and aesthetically, guided by visual intuition and cultural experience.

Such patterns are commonly found in traditional visual practices, rooted in creativity passed down through generations. The artisans of Amanuban developed these motifs not through formal geometric instruction, but through spatial reasoning shaped by the daily practice of plaiting. This demonstrates that geometry is not confined to academic contexts, but is a living expression embedded in cultural traditions.

In educational settings, these motifs offer rich opportunities for introducing mathematical concepts in a contextualized and meaningful way. The patterns can serve as instructional tools for topics such as plane figures, geometric transformations, and non-regular tessellations, applicable across both primary and secondary school levels. Incorporating local motifs into mathematics instruction aligns with the Merdeka Curriculum's emphasis on contextual and experiential learning. This approach enriches students' conceptual understanding while fostering an appreciation for indigenous knowledge and cultural heritage as integral components of mathematical education.

The identification of tessellations within traditional plaiting craft motifs of the Amanuban community aligns with previous research showing that local cultural patterns encapsulate mathematical principles. Apiati et al. (2018) identified tessellation concepts in the plaiting crafts of Kampung Naga, while Ali & Davis (2023) highlighted tessellated structures in Adinkra and Kente motifs relevant to geometry education. Karimah et al. (2021) revealed geometric transformations and tiling in Trusmi batik, and Siswo (2019) described the application of tessellation in Pulobandring's traditional plaiting patterns. Yadnya (2016) also identified tessellative features in ceramic and *vavin* products, including planar shapes, symmetry, and geometric transformations. Collectively, these studies support the conclusion that Amanuban plaiting motifs constitute tangible mathematical constructions that can be used as culturally grounded, authentic learning resources through the lens of ethnomathematics.

The tessellation patterns found in Amanuban traditional plaiting crafts hold substantial potential as authentic instructional materials for mathematics education at various levels. Concepts such as plane shapes, symmetry (vertical, horizontal, and rotational), geometric transformations (translation, rotation, reflection), pattern recognition, and spatial reasoning can be introduced contextually through visual and constructive exploration of these motifs. At the primary school level, patterns based on regular tessellations such as repetitive square arrangements forming rows and columns can serve as engaging media for introducing geometric shapes, symmetry, and repetition. Students can observe repetition directions and rearrange square units to better understand congruence and translational principles.

In junior high school, semi-regular motifs such as parallelogram arrangements forming cube illusions or dodecagon-like patterns offer opportunities for students to explore rotation, reflection, and combinations of more complex geometric shapes. Analyzing the arrangement of these forms can deepen their understanding of order and symmetry in two-dimensional space.

At the senior high school level, students can engage in more abstract analysis of non-regular tessellations, such as irregular patterns that still cover the plane without gaps. They can investigate the abstract conditions required for tessellation, differentiate vertex types, and identify geometric transformations translation, rotation, and reflection within the structure of the motifs. Patterns that create the illusion of three-dimensional cubes or consist of non-congruent shapes can enhance learning in spatial geometry and visual reasoning.

The integration of tessellated motifs supports the ethnomathematical approach by bridging formal mathematical knowledge with local cultural practices. This strategy aligns with the goals of the Merdeka Curriculum, which promotes contextual, student-centered learning grounded in learners' environments and cultural experiences. Using local motifs in instruction not only makes learning more relatable to students' daily lives but also strengthens awareness of cultural richness and ancestral knowledge.

Learning activities such as guided projects or exploratory tasks like observing and reconstructing simple plaiting patterns allow students to discover mathematical concepts independently within authentic cultural contexts. These activities make mathematics more meaningful and connected to real life, fostering the development of mathematical literacy, creativity, and a deeper appreciation for their own cultural heritage.

CONCLUSION

The analysis of traditional plaiting craft motifs from the Amanuban community reveals that the resulting geometric structures represent various types of tessellations, including regular, semi-regular, and non-regular configurations. These patterns not only adhere to the principle of completely covering a plane without gaps or overlaps but also demonstrate the application of geometric transformations such as translation, rotation, and reflection. Although created through generational cultural practices, these motifs embody complex mathematical constructions, affirming that local knowledge contains legitimate mathematical content that can be interpreted within a formal framework.

Each type of tessellation identified possesses distinctive characteristics and integrative potential aligned with specific educational levels. Regular tessellations, such as square-based patterns, can be used to introduce plane figures and basic transformations at the elementary school level. Semi regular tessellations that produce spatial illusions are well suited for reinforcing concepts of symmetry and shape combinations in junior high school, while non-regular tessellations comprising irregular forms and pseudo three dimensional motifs offer opportunities for more abstract analysis at the senior high school level.

The integration of plaiting craft motifs into mathematics instruction supports the ethnomathematical approach, which bridges formal mathematical concepts with local cultural practices. This approach has been shown not only to enhance students' conceptual understanding and mathematical literacy but also to foster cultural identity and appreciation for indigenous knowledge. Accordingly, this study affirms that the plaiting craft motifs of the Amanuban community represent an authentic, meaningful, and contextually relevant educational resource for implementing the *Kurikulum Merdeka* (Independent Curriculum).

As a follow-up to this study, it is recommended that teachers and curriculum developers systematically incorporate local cultural motifs such as those found in Amanuban plaiting craft—into mathematics education, particularly in topics related to geometry and transformation. Educators should be provided with contextual training and instructional guidelines to effectively adapt cultural artifacts as teaching resources. Further research is also encouraged to explore additional forms of mathematical representation embedded in local cultural practices, using both qualitative and quantitative approaches, in order to develop more comprehensive, transformative, and culturally grounded instructional models. Moreover, the active involvement of Indigenous communities and cultural custodians is essential to ensure the authenticity and sustainability of these educational resources within the school system.

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